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THE DRAGON-FLY

OR

REACTIVE PASSIVE LOCOMOTION

A VACUUM THEORY OF AERIAL NAVIGATION BASED ON THE PRINCIPLE OF THE FAN-BLOWER

LONDON
CHARLES WHITTINGHAM AND CO. CHISWICK PRESS
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1882

Price Six Shillings

James Brady
from his friend
Thaddeus Hyatt

THE DRAGON-FLY.

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OR

REACTIVE PASSIVE LOCOMOTION.

A VACUUM THEORY OF

AERIAL NAVIGATION,

BASED ON THE PRINCIPLE OF

THE FAN-BLOWER.

TO WHICH IS APPENDED SOME REMARKS ON

WATER AND ITS NAVIGATION.

BY

A DISCIPLE OF BACON.

> "The tales of Antiquity—the poetical productions—the religious tenets—and even the Hiſtories of moſt nations "ſhow that to acquire the Art of Flying, or of imitating the birds, has been the earneſt deſire, and has exerciſed the "genius of mankind in every age."—*Hiſtory and Practice of Aeroſtation, by Tiberius Cavallo, F.R.S.* London, 1785.

Waſte marks the imperfect works of man:
Economy the perfect works of God.

(Author's Edition.)

LONDON:
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A PREFACE AND AN APOLOGY.

MY apology for writing this book is contained in what follows :—

In the year 1857-58 I offered a reward of $1,000 to any inventor able to produce an actual flying machine. This offer was made through the columns of a leading ſcientific journal in America, and kept open for a year, but failed of its object. Some time after this, while living abroad in an old city of the Continent ſituated by the ſea, famed for its ancient hiſtory and modern brandies, I ſet myſelf ſeriouſly to the taſk of carefully watching the motions of birds in the air, with the view of aſcertaining by actual obſervation of their wing-movements in what the ſecret of flying conſiſted. Theſe obſervations were kept up by me for many years—for fully ten or eleven—with little or no intermiſſion, when they were ſuddenly diſcontinued. Why my work was recommenced, and why theſe pages have been written, I will now proceed to tell, though fully aware of the ridicule it muſt neceſſarily expoſe me to from that claſs of remarkable people in our world who underſtand the whole mechaniſm of material nature, and the ſpiritual or effluent laws of the univerſe ſo much better than their more ignorant and to-be-pitied fellow-creatures do.

During my reſidence in the old city by the ſea, as I have ſaid, I ſtudied the birds carefully. Bats alſo intereſted me, and there were plenty of them there. Of inſects, however, I took no notice, except as to butterflies, on account of their large and ſlow-moving wings, which could be eaſily watched; for what could creatures with comparatively no weight at all teach in reſpect to a problem the very gift of which relates wholly to *weight!* for the problem of aerial navigation is the problem of a flying man: a flying horſe: a flying elephant: a flying *mass:* a ton, or tons of matter going through the air: and the largeſt birds we know of, or can imagine, the *roc* of fable, and the winged dragons of ſtory, come neareſt as exemplars of the kind of flying and flying creatures we need to conſider in order to diſcover the wonderful ſecret of locomotion through the air. Evidently in ſuch a field the inſect world with its pith-like bodies has no ſtanding. Of courſe I did not ſtudy *inſects.*

But in the daily rambles I was accuſtomed to take around the ruined ramparts of the old hiſtoric city, one creature of the inſect world ſingled me out for his attentions, and, in a ſenſe, became my companion for years, following me from city to city, and from continent to continent, making itſelf known to me under circumſtances and in ways ſo peculiar, that I was at length compelled to notice and conſider it. I obſerved the creature at firſt from ſomething ſtrange in the way it flew about me. I cannot ſay that at the time I actually thought it was trying to attract my attention, but it flew near me and around me in circles that were ſignificant enough to make me look at it with a perception of ſome obſervable difference from its ordinary flying: and this took place uſually at moments of deep thought. Walking as one does with his eyes wide open and looking at objects about him, the phenomenon never happened. The inſect, indeed, might have been as much about me then as at other times; but if ſo, it was following its purſuits in its ordinary manner, and doing nothing to ſpecially call my attention to it. Its peculiar movements, and thoſe that forced me to look at it, invariably took place during certain conditions of my own mind and thought—the condition being one of intenſe and profound abſtraction:—with the whole natural world ſhut out from view: ſuch moments of exiſtence as one lives in a ſpeculative world; a world where "objective ſubjectives" are paramount. It was at theſe times, when the mind, ſtrained to its utmoſt in the effort to extract from previouſly obſerved phenomena in nature their ſecret principles: to detect as it were the hair-ſpring of ſome ſpiritual mechaniſm coiled up within the world of things:—it was, I ſay, at ſuch moments of abſtraction that I would ſuddenly be brought back to the conſciouſneſs of a natural world and material things by the *feeling* of a material preſence about me; and one object invariably, and *always* the one object, at ſuch times met my abſtracted gaze—

A Dragon-fly!

What I thought or how I felt when this firſt happened I cannot now tell. One never notes particularly the firſt link in the chain: it is only when the ſeparated and detached links faſten themſelves together and become *a chain* that human obſervation is ſufficiently arreſted to note and draw concluſions. Naturally I looked at the creature—but only vaguely: I really couldn't have told at the moment why I looked at it: I didn't know myſelf: and when I did it was a—diſappointing look, for the flaſh of its wings was like the lightnings at play in the clouds: I could ſee the flaſh, but with no chance to ſtudy it: and my deſire was to underſtand the *mechanical movements* of wings! So if I did pauſe to look at the creature it was to only look away again and think no more of it: until a like occurrence again took place, when the ſame proceſs of looking at, and looking away, and forgetting, would be gone through with as before; but with apparently no practical reſults of any moment whatever. Theſe things occurred conſtantly during a period of years, but with no greater effect on my mind than to make me regard the coincidences as peculiar and curious. But when the ſame thing again took place on my return to America, and with the ſame regularity (though poſſibly not ſo frequently) as before, my attention became ſomewhat arouſed: particularly after the following occurrences. Having ſeen in the photographic gallery of an artiſt friend in Waſhington, D.C., a picture of what he called a flying machine, and feeling curious to ſee it, I went out to the place where I was told I ſhould find not only the machine but the inventor, an old Frenchman. Arrived at the grounds of "The Waſhington Obſervatory" (for this was the place I was told to go to) the firſt object that met my eyes as I entered the grounds was *a dragon-fly!* The poor little fellow was helpleſs and a prisoner; caught in the web of an enormous ſpider, and ſtruggling vainly to eſcape. It is ſcarcely neceſſary for me to ſay that I loſt no time in ſetting him free. I not only took him out, but releaſed him from every filament in which he was entangled; and had the ſatisfaction of ſeeing the flaſh of his beautiful wings as he ſailed gracefully away through the air. (The Frenchman and his machine I did not ſee.) But I could not help but be ſtruck with the ſtrangeneſs of *this* "coincidence." I, in purſuit of a flying machine and its inventor, confronted again by a *dragon-fly!* and the very *firſt* thing too, to be ſeen by me! Can anyone wonder that I should *now* begin to think of the poſſibility that ſomething in the nature of a *principle* and a *diſcovery* might be lying ſomewhere *behind a dragon-fly?* But the "manifeſtations" did not ſtop here. What had thus far taken place, was as nothing to what I was yet to witneſs. And here I muſt pauſe for a moment to ſay that I ſhall have no word of condemnation for anyone (who does not perſonally know me,) who after reading what I am now about to relate, may ſay—"*I don't believe a word of it!*".

When in the life of ſome one man occurrences foreign to the run of human experience take place, not only have mankind the right to challenge them, their verity, and the relator's ſanity, but he himſelf, in the intereſt of his own common ſenſe, is bound to do the ſame; and this is exactly what I did and what I have always done through life. I think no one in the preſent caſe can fairly charge me with any very great haſte to ſwallow the incredible, conſidering that the phenomenon ſpoken of was a conſtantly recurring one during a period of at leaſt ſeven full years. A man who wouldn't or couldn't have his eyes opened to a *fact* during this length of time muſt be either a very "great" philoſopher or a very *old* one; the latter, I ſhould ſuppoſe, ſomewhere of the tertiary period, poſſibly earlier.

After having releaſed the little dragon-fly from the ſpider's web in the grounds of the Waſhington Obſervatory, I had occaſion to go almoſt immediately to Philadelphia, a diſtance by rail of 140 miles; and the day following my arrival was the Sabbath: a warm, ſweet, bright ſummer's day. I had for years been in the habit of noting my obſervations of flying creatures under the head of "Thoughts on Flying," and this day was buſily occupied in doing the ſame. I was alone in the room ſitting before an opened window, my whole attention occupied in writing, when the dragon-fly once more made his appearance, this time planting himſelf unceremoniouſly on the table alongſide of my manuſcript. I was both delighted and ſurpriſed, not to ſay a good deal *ſtruck.* A large bell-ſhaped glaſs being near at hand, I placed it over the creature as quickly as poſſible, but I might ſeemingly have been as deliberate as I liked, for the fly ſhowed not the ſlighteſt inclination to ſtir. Doubters will ſay, "Oh, the poor creature was ſtill becauſe it was *tired.* Very likely it had juſt flown from a long diſtance." Very likely, for it looked *exactly* like the little fellow releaſed by me from the ſpider's web 140 miles away two days before! Yes, it was moſt likely "tired." But mind! I don't ſay it *was* the ſame fly! My readers may ſay or think anything they pleaſe; my buſineſs is to relate occurrences *truthfully* and ſtate *facts*, and I will relate truthfully the occurrences that now took place. The fly, remember, is now under the bell-glaſs, and, addreſſing it as if ſpeaking to an intelligent being, the following took place:—(To the fly) "My little friend, what has brought you here? Have you come to ſhow me ſomething about flying? Well, how is it done? What *is* the ſecret? Let me ſee you fly!" And the creature, until now quite ſtill, at my bidding was up inſtantly in the air within the bell-glaſs, flitting about in all directions, and ſo continued until I ſaid to it, "*There, that will do; you may ſtop!*" And the fly again ſettled upon the table within the glaſs. I now looked at the creature as ſcrutinizingly as poſſible. In the motion of its wings while flying I had been unable to diſcover anything. I now felt curious to have a look at them in repoſe, and were I to live a thouſand years I could never forget my ſenſations, when, ſaying to it (but without really believing it would be done), "*Now let me ſee your wings!* SPREAD THEM OUT!" and inſtantly the four little goſſamer wings ☞ *trembled and ſpread themſelves out on the table* viſibly before my eyes!! But ſtill I could ſee nothing to give me a ſingle hint in the direction of my thought. I ſtill aſked myſelf as vainly as before, what *is* the ſecret of flying? And, if poſſible, I felt more diſcouraged than ever, for here, with this flying creature before me, near to my very eyes where I could ſee it, obedient ſeemingly to my will, and offering the mechaniſm of its wings for my inſpection, ſtill I did not get the clue to a ſingle thing. I again told it to fly, and it did preciſely as before—flying while I wiſhed it to, and ceaſing to fly at my command, and yet all remained as dark to me as ever. The purſuit ſeeming fruitleſs, I put an end to the experiments by raiſing the bell-glaſs and ſaying to the obedient creature, "There, you may go now, my little fellow; I cannot really underſtand what it all means, but I won't keep you a priſoner any longer. Go!" And, at the word, he darted out of the window. But although I felt diſcouraged at the time, and could ſee no meaning in the pertinacity with which the dragon-fly purſued me, I think I ſee it *now*.

Until the dragon-fly made its appearance, my thoughts on flying were running in the old grooves in which the thoughts of all men had been running for centuries, and running with utterly barren reſults, viz., "beating the air as *birds'* wings do!" *ſailing* on "inclined planes," &c. &c.

And now comes along a creature viſiting me ſo conſtantly, and in ſo many wide-apart places, as to compel me to think of *inſects*, and give *them* attention; ſo that finally, after long years have paſſed, I get to underſtand that behind the dragon-fly is to be found the great law of VACUUM OR FORCE-FLOTATION, *the condition precedent to all navigation of the air!*

But although I felt greatly diſappointed at the time with the reſults of my experiments with the dragon-fly in the bell-glaſs, I did not at once abandon my purſuit of the ideal ſecret. I continued to watch the birds, and ſometimes inſects, and record my "thoughts on flying" as regularly as ever; and by-and-by I got hold of a little thread, that became to me finally the *ſcarlet clew* out of the labyrinth I was in; and to teſt the correctneſs of my thought at the time, I made an experiment with an *inſect* (the miller or moth ſpoken of in the treatiſe following). After this I made four large wings in perfect imitation of the dragon-fly, conſtructing them of reeds for the nervures, and calico for the membranous covering.[1]

There are ſome old boys now living who remember the advent of india-rubber *balls*, and their marvellous power of getting high up into the air, beating the old particoloured leather-covered fellows "all hollow;" and with the ideals of ſuch india-rubber performances in a boy's brain, nothing was eaſier or more natural, when the announcement came that india-rubber *ſhoes* were in the market, than for him to fancy that, with a pair of theſe on his feet, leaping five-rail fences, or even ten, would be a trifling paſtime. My father aſſured me I was miſtaken, and would be diſappointed; but I ſaw myſelf ſo plainly in the air, bouncing up on india-rubber ſhoes, that nothing but india-rubber ſhoes would pacify me, and they were bought. I could hardly reſtrain my childiſh impatience; but inſtead of finding myſelf ten feet high in the air, I found myſelf twenty feet deep in the ſlough of diſappointment and chagrin: my india-rubber ſhoes wouldn't bounce me a bit! Ah, thoſe ſhoes! I ſhall never forget them. But who is there that has not had his india-rubber ſhoe experience? Alas for the viſions of childhood! Alas for the ideals of youth!

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[1] There is nothing ſo ſatisfactory or delightful to an inventor as *ideal* mechanical conſtructions; all the parts are ſo perfect, move with ſuch preciſion, and with no friction; and then, too, everything comes out *exactly* in accordance with your theory.

The peſt of an inventor's life is that his *facts* won't accommodate themſelves to his *theories*. About the time I conſtructed my dragon-fly wings, I was ſeeing myſelf in the air, and flying about on them as lively as in earlier days I had ſeen myſelf bounced about on the india-rubber ſhoes, and my impatience to get out into the country to put them on and try them, was fully as great as in the caſe of the ſhoes. So I ſtarted for the country, and from London went down to Maidenhead, putting up at an old farmhouſe on the downs. My brother-in-law, and the machiniſt who had made and arranged the mechaniſm for my wings, were with me. For obvious reaſons, I thought it ſafeſt to not try the performance in open daylight: ſo about two o'clock in the morning we took up our poſitions on a hill near the houſe, for I concluded that for a *firſt* experiment it would be glory enough to do it by *running down* hill, leaving for a time the more ambitious and pretentious up-from-the-ground method to the bird. It took my machiniſt, oh! *ſuch* a time to get thoſe four great wings (nine feet long each) properly fixed on to my back and ſhoulders! (I can feel the weight of them now on my poor old back when I think of it.) But then there was glory before me, and what won't a man (or a woman) do for glory! The moments of wing-fixing ſeemed to be hours; and then, too, ſpectators came, and I wanted no ſpectators; they were, however, only horſes: they came neighing up, arranging themſelves in a great circle, each one ſtanding in an attitude of trembling fear, and ready for a bolt at a moment's notice, but filled with ſo much curioſity as to compel them all the time to draw nearer and nearer. There was ſomething marvellouſly impreſſive in that night ſcene. I never think of it without almoſt feeling the breath of thoſe timid, curious, trembling horſes—now approaching, now receding, coming cloſe up, then galloping away, and then again returning: and the ſolemn miſtineſs of the dewy midnight air: the four great white wings! the low tones of the ſpeakers: and the *preparation!* and what was to come of it! the expectations! the *anticipations!*

Alas! for the vanities of earth: alas! for human intellect! for human mechaniſm! Diſappointment! and diſappointment only. I tried to run down the hill: the machiniſt ſupported me on one ſide, my brother-in-law on the other: we all ran down together as well as we could, a ſort of partnerſhip and combination fly, the courſe downward rather zig-zaggy: and my poor *legs!* I cannot ſay which was moſt to be pitied, legs or back. I thought I had about ſeventeen hundred pounds of old iron on my ſhoulders: why my legs did not break in that run down hill I don't know; but the ſix-rail fence at the bottom of it was not *ſailed over* by me as I had ſeen myſelf ſailing in imagination—nor the next field, nor the barn!

And I felt juſt as glad to get "them" wings off again as I had before felt impatient to feel them on. I didn't believe as much in flying after I tried it as I did before: and I haven't hankered much after it ever ſince.

There are, no doubt, a good many four-ſquare ſort of people in the world who will ſay that after ſuch an experiment I ſhould have turned my back on the dragon-fly. I did not do it right off, but I did after a while; and I am afraid that the mortification of my failure when the horſes witneſſed my defeat may have had ſomething to do with it; partly this, I think, and partly the conviction felt by me that others more favourably conditioned for the work than myſelf were ſure to accompliſh it; for the mind of the world had become greatly ſtirred up on the ſubject of "Aerial Navigation" ſince my thoughts had been firſt turned towards it.

From the hour when I gave up thinking about flying, *I ſaw no more dragon-flies.* From this hour, too, miſfortunes began. The man known as "the lucky" became the moſt unlucky of mortals: matters proceeding from bad to worſe, until I found myſelf reduced to the mental ſtate of the afflicted Job, and the deſpairing condition of Jonah in the belly of the whale.

How it happened I cannot exactly ſay, nor would it matter if I could, that one day in converſation with a friend, a devout believer in the neceſſity and certainty of air-navigation, I was ſuddenly impreſſed to ſay to him, "Lyman! it juſt occurs to me that my paſt ſeven years of misfortune are judgments upon me for my neglect of duty! Jonah was ſent to preach to the Ninevites, and he wouldn't go; and got paid up for it by getting into the whale's belly, where he had to ſtay till his common ſenſe returned to him; but the minute his toes touched dry land he drew a bee line for Nineveh! *And this is what I mean to do!* I had a 'miſſion,' and ſhould have gone ahead on the flying problem: I dropped it, and neglected it, and look what has happened to me! From this moment I will imitate Jonah, and pull foot for Nineveh! *I'll return to duty!* I'll go to work again at the flying problem!" All which I began at once to do. A few nights after this I fell aſleep with my laſt thought on flying, and before it was fairly light awoke the next morning with an ideal flying machine in the ſhape of a dragon-fly ſharply defined in the airy viſion of my brain. While I was conſidering it, a loud noiſe was ſuddenly heard in my room, *the ſound of wings*, and powerful ones too, ſo powerful as to ſtartle my wife, who exclaimed quickly, "*What is that?*" I liſtened for the ſound again, and when it came I replied, "*It is the dragon-fly!* I have not ſeen him for years, but he knows now that I have returned to duty, and has come again to encourage me!" In a ſhort time the light of the morning became ſufficient for me to ſee, and going over to the corner of the room from whence the ſound had ſeemed to proceed, there uproſe at once before me the largeſt and moſt beautiful creature I had ever ſeen; ſo majeſtic and graceful and grand as without hyperbole to be worthy of the title King of the Dragon-Flies! Addreſſing him, I ſaid, "I know what you have come for! It's all right! Good-bye!" and drawing aſide the lace curtain from the open window, my viſitor darted out and diſappeared.

And this is why I have written this book. I cannot ſuppoſe that I ſhall tell all that needs to be known to make the navigation of the air poſſible. No cauſe and no science is ever made by one man; in fact, men *create* nothing: we can only imitate Nature; and we *know* only what is *given* to us; our reſponſibilities are limited to what we *can* do; and though it be but little we are able to accompliſh in the world's long hiſtory, it matters not where each one performs his Divinely allotted part. The general may get the glory of the battle, but the humbleſt ſoldier who has performed his duty in the field has always within his own breaſt the conſciouſneſs and the ſatisfaction of a duty done and commendation earned: and our great Milton ſays:—

> "*They alſo ſerve, who only ſtand and wait!*"

T. H.

INTRODUCTION.

THE problem of flying is the problem of the ages:—towards its ſolution the hearts and hopes of men have ſteadily ſet through all the generations. Who has not dreamed of flying? That he flew? And the delight! And is it but a dream? Has this yearning of the human heart, coming down to us through all the centuries, through all hiſtory, all tradition: an inſtinct like that for immortality; a born prophecy within us; has it been given to us, never to be gratified—never to be fulfilled? The embryo foretells a birth, the petal's folded leaves a flower. The rootlet in the dark below the ſurface of the ground, turns from its courſe, obedient to an inſtinct that points it to the living water that it thirſts for. How could it turn were not the waters there? And will God mock the human ſoul? Shall all its prophecies prove falſe? Believe it not! He, who is faithful to even the tiny rootlet in the earth, will be alſo faithful to the creatures made by Him, with yearnings for a loftier, nobler, and happier exiſtence.

When we conſider that daily, for a period of nigh ſix thouſand years or more, God, the Creator, has been demonſtrating the poſſibility of aerial navigation, by the flying of creatures practically of the ſame ſpecific gravity as men, it ſeems amazing that the ſecret of flying ſhould have remained ſo long a myſtery: man's ignorance of it, more myſterious ſtill! A myſtery admitting but of one explanation: the will and providence of God.

No man can diſcover until it is *given to him*, until then the eyes of men are blinded. The building cannot be made until the foundation is laid. God prepares mankind for the events of His providence. The hiſtory of the world ſhows that great events are preceded invariably by others of equal ſignificance as forerunners. Diſcoveries are like the links of a chain; like dependent parts of a machine. Invention is made up of diſcoveries precedent and diſcoveries conſequent.

Juſt now, God has made it for the intereſt of men to foſter electricity—*fortunes in electric lights!*—the Stock Exchange gone mad! ſtimulus to invention hand in hand with ſtimulus to greed; but all in preparation for the greater thing to come, the aerial railway of the ſkies! the great highway of nations! the univerſal belt and bond to bind together in one common tie, all tribes, all caſtes, ſects, creeds, communities, nationalities, and governments in one grand unity of univerſal brotherhood, the common family of man.

When Dr. Franklin and his confrères of the Academy of Sciences, juſt one hundred years ago, witneſſed the aſcent in a Montgolfier balloon of the firſt human being who had ever thus penetrated to the region of the clouds, the world imagined the myſtery ſolved and aerial navigation an accompliſhed fact. In his book, Cavallo ſpeaks of it as "the art of travelling through the air . . . . *at laſt diſcovered!*" And yet the world to-day, with regard to flying, ſtands juſt where it ſtood then; not one ſingle inch advanced. No regular balloon-ſteamers between London and Paris; no aerial clippers to or from New York, China, or Japan; no winged Nihiliſts, Socialiſts, or Red Republicans hatching conſpiracies among the clouds and hurling dynamitic thunderbolts upon the devoted heads of unhappy Czars, Emperors, and Kings.

Livingſtone, Speke, Stanley, and other African explorers have had to "do" the ſources of the Nile, the myſtic Niger, and the Mountains of the Moon, in the old foot-ſore way. Travellers continue to be eaten up by cannibals; and the cold ſpit of the North Pole is ſtill run through the vitals of unlucky Arctic explorers. In ſhort, the *bird* continues to be "maſter of the ſituation," and man, the evolutionized ape, the laughing-ſtock of all the inſect world and feathered tribes!

WHY?

CHAPTER I.

REACTIVE LOCOMOTION.

An Inventor's Maxims.

I know nothing until *I try*. The way to diſcover is to *doubt*. The way to invent, do it *the other way*. Everything that *ought* to be done, *can* be done. Nothing is "good enough" that can be done better.

Winds or Force-denſity in the Atmoſphere the ſource of Aerial Locomotion.

"A moderate wind moves at the rate of ſeven miles an hour, a ſtorm at thirty-ſix miles, a hurricane at eighty, whilſt air ruſhing into vacuum at 32° Fahr. and barometer 30 inches, reaches the velocity of 884 miles per hour."

Lardner's Philoſophy.

AS far as we can glean anything from fable and hiſtory, the *Firſt* and Original Theory upon which mankind proceeded in their attempts at locomotion in the air, was the *Bird*-Theory.

The *Second* Theory, originated juſt one hundred years ago, and was the *Balloon* Theory. All attempts at air navigation baſed on theſe two theories have failed.

I now offer to the world a *Third* Theory. The number three is regarded by many as the "lucky number," ſo that we have the expreſſion in common uſe, "the *third* time is always ſure to win." . I venture to hope that it may in this caſe prove true.

The wind that oppoſes the bird is alſo the power that floats it; and the problem of locomotion in the air for all the creatures that fly in it is one of flotation primarily, from whatſoever ſource or by whatſoever means the wind-preſſures may be induced.

The men of 1782 were quite right in regarding flotation as the pivot in the problem, wrong only in miſtaking ſpecific-gravity-flotation for the method of Nature. And thoſe who before and thoſe who ſince 1782 have theorized and experimented to ſolve the problem of aerial navigation have failed becauſe their attention has been wholly fixed upon the machine or flying creature inſtead of the atmoſphere. It is not the machine or the flying creature we need to change, but *the air*. The atmoſphere is too light to buoy us up. We muſt *change the ſpecific gravity of the air*.

The Montgolfiers and men of Franklin's day attempted to ſolve the problem by changing the ſpecific gravity of the machine or flying creature, with not a ſingle analogue in Nature to juſtify them, and later experimenters have dealt with the queſtion as one of *projectiles*.

Birds ſail or glide through the air by employing their weight as projectile force. Birds are floated through the air by the force of the winds. Birds with no wing movements are impelled through the air as weighted and balanced inclined planes operated upon by combined wind forces, the impulſion producing *paſſive* locomotion. Birds hover or ſtand ſtill in the air under the combined operation of winds and wings. And birds mount into the air and urge themſelves forward under the action of their wings in their dual capacity of fan-blowers and propellers. Bats and large-winged light-weight creatures are *animated parachutes.* But the

Inſect world, repreſented by the Dragon-fly,

have an aerial locomotion of their own, baſed on relatively ſmall wings driven at high velocities on the principle of the fan-blower, their movements through the air not being the reactive direct locomotion that reſults from the play of wings when employed in their combined dual capacity of fan-blowers and propellers, but the reactive indirect or *paſſive* locomotion reſulting from the employment of wings in their ſingle capacity of *fan-blowers.* This ſpecies of inſect locomotion is analogous to the paſſive locomotion I have mentioned where the bird is *impelled* by the action of combined wind-forces directed againſt the balanced body of the creature as a weighted inclined plane; the difference being that in the caſe of the inſect the wind-force and preſſures originate in the inſect, but in the caſe of the bird the wind force and preſſures originate not in the bird but in the vaſt magazines of external nature.

It ſeems preſumptuous for any man to ſay, "I have diſcovered what mankind during thouſands of years have ſought for in vain!" And it is preſumptuous. Therefore I will not ſay *I* have diſcovered. If any man could have *diſcovered* the ſecret of flying, Pettigrew, I think, is the man, for he comes nearer to it than any other; and yet, ſtrange to ſay, he attempts to controvert the theory of Borelli, who wrote in 1680 on the action of the wings, and of Profeſſor Marey, who wrote in 1869 advocating Borelli's theory becauſe ſubſtantiated by his own experiments; both Borelli and Marey being quite right, and Pettigrew quite wrong. Nevertheleſs, Pettigrew, in his book "Animal Locomotion," has enunciated more ſound philoſophy on the ſubject of flying, and has ſhown a deeper inſight into the true principles of bird performances, than any other writer whoſe views have fallen under my eye. Take for example the following:—

"The wing of a flying creature, as I have taken pains to ſhow, is not rigid; neither does it always ſtrike the air at a given angle. On the contrary, it is capable of moving in all its parts, and attacks the air at an infinite variety of angles. Above all, the ſurface expoſed by a natural wing, when compared with the great weight it is capable of elevating, is remarkably ſmall. This is accounted for by the length and the great range of motion of natural wings, the latter enabling the wings to convert large tracts of air into ſupporting areas. It is alſo accounted for by the multiplicity of the movements of natural wings, theſe enabling the pinions *to create and riſe upon currents of their own forming*, and to avoid natural currents when not adapted for propelling or ſuſtaining purpoſes. (See Pettigrew's "Animal Locomotion," pp. 218, 219.)

The words I have italiciſed, "to create and riſe upon currents of their own forming," expreſs really the giſt of the problem to be ſolved, and yet Pettigrew himſelf evidently failed to perceive it, or he would not have elaborated ſo extenſively his "figure of 8" theory, and neither would he have condemned Profeſſor Marey and Borelli as he has done. Nothing is more common in invention than for a man to have a diſcovery in his hands and not know how to uſe it, and the difference between the machine that ſucceeds and the one that don't, is ſo exceedingly fine oftentimes that the unſucceſsful inventor feels himſelf aggrieved by the ſucceſs of the other whoſe machine he conſiders to be "exactly like" his own, and yet his own won't work and the other will. But the world judges by *reſults*.

The miſtake of mankind has been in trying *to fly*. If the ſimple theory that I ſhall endeavour to ſet forth in the following pages ſhould prove to be the correct one, then the world has been fooling itſelf for ages with wing movements—"wave" theories, "rowing motions of the wings," "heated air-cells," "hollow bones and quills," "inclined planes," "aero planes," "twiſted planes or ſcrews," "figure of eight" theories, "anterior and poſterior margins" of the wings, &c. &c.,—and numberleſs creatures, inſects, and birds, have all been tortured and experimented on to no uſeful purpoſe whatever.

What man needs to know, and what he muſt know before the deſert ſpaces of the air can poſſibly be traverſed by any mechaniſm ſhort of God's creating, is by what proceſs, by what agency, by what contrivance, can human ingenuity and human ſkill ſucceed in charging the atmoſphere with Force!—lifting force, floating force, impelling force.

The atmoſphere charged thus with force would then become the active agent and propel the machine. Birds propel themſelves. The dragon-fly, holding itſelf on an even keel, travels as well backwards as forwards, being under the influence of a wind-preſſure external to but created by itſelf, a wind-preſſure that the creature by its own will controls at pleaſure, and can with the quickneſs of thought ſhift from one ſide to the other—to front, to rear, to up, to down—to any and every point within the hollow concaves of the domed ſphere of which it is at once the centre and the animating ſoul; a ſphere that goes with it and that makes it independent of the external forces that roll and ſurge through all the regions of the air.

To navigate the air, the firſt thing in order is to be able *to float* in it. This can be done evidently in but one of two ways; either we muſt make ourſelves lighter or the air heavier. Making ourſelves lighter has been tried for a hundred years and failed every time. Nothing remains, therefore, for us to do but to make the air heavier, and as it is manifeſtly impoſſible to change the chemical conſtituents or ſpecific gravity of the atmoſphere, we muſt accompliſh the ſame thing practically in another way.

Given, the power to create a wind blowing at the rate of 884 miles an hour—and what couldn't we lift and float! Hurricanes with a tenth of this power unroof houſes and pick up ploughs and people from off the face of the ground and tranſport them long diſtances. Evidently we only need the power and machinery to create a *wind-fulcrum* in the air and control it to our liking, and we may travel where the condor ſoars, and the albatroſs ſails, and the bald eagle nurtures its young in the clefts of the crags!

But the wind-force muſt be our own and independent of Nature. Aero-planes, and inclined planes, and twiſted planes, are things for the winds of the firmament to diſport themſelves with, and hurl into fragments and ruin. Man may not be the plaything of the tempeſts. He muſt be the maſter of a tempeſt of his own,—that he can carry with him and about him, and, as it were, enwrap himſelf withal as with a veſture and a garment,—and, panoplied therewith, to meet the marſhalled winds of heaven on their own battle-field and vanquiſh and defy them all!

This, would be true Flying!

This, would be the Navigation of the Air!

The winged ſtorm-kings conquer by yielding; by compromiſe; by accommodation. This, man can never do, for without life in them there can be no wings. It is the life that is in the wing that makes it a wing. I mean to ſay it is life, and life only, that can give wing-function.

And mankind have been experimenting with dead planes.

Is it any wonder that they have failed?

Of what uſe the anatomizing of and the philoſophizing on wings when it will remain for ever an impoſſibility for men to uſe wings? There are no wings *for man!* and never can be; and this is why "the figure of 8" theory and all other theories baſed on the idea of the poſſibility of employing wings *as* wings are a miſtake.

What could come of *dead* wings, but "dead failures?"

It is not wings that we want—but *wind-blaſts*, *wind-power*, *wind-flotation*; and wings *as* wings, as birds uſe them, man cannot get becauſe all his imitations are dead—dead—dead! and to be dead is to be without function. Is a marble ſtatue a man becauſe made in the image of a man? Neither are the things called "wings," of man's make—*wings*.

Mankind muſt for-ever diſmiſs the thought of "wings," or they will never navigate the air.

Flying is therefore an impoſſibility.

But locomotion through the air is poſſible.

Many manufacturers in the United States are now turning fan-blowers to account by employing the ſuction-power of the machine to free their ſhops from the duſt and débris incident to their work; ſhavings and ſawduſt as well as other duſt riſing up from the floors and benches like flying creatures, and directing their ways ſtraight for the ſuction canopy and pipe, up through which they diſappear. I was told by a friend that the ſuction of the fan-blower at his works was ſtrong enough "to lift a man's hat right off his head:" and he mentioned the fact that one of his men in walking under the canopy had his hat lifted from his head and carried up the pipe. The incident to me has a peculiar ſignificance from the connection it ſuggeſts between fan-blowers and inſect locomotion in the air. The buſy bee is a fan-blower, and the creatures, as is well known, ventilate their hives by the play of their wings: the bees aſſigned to this duty placing themſelves in the paſſages and at the entrances to the hive, and by the play of their wings, as in flying, creating a perfect draught.

The moderate wind moving at the rate of ſeven miles an hour, and the ſtorm moving at thirty-ſix miles an hour, and the hurricane moving at eighty miles an hour—are all ruſhing into vacuum, or trying to, juſt as really as the wind moving at the rate of 884 miles an hour.

But for the vacuum centre in the fan-blower the man's hat would not have floated: and but for the vacuum centres ſomewhere in the atmoſphere, we ſhould have no winds and no bird-flying: and but for the vacuum centres produced by the wings of inſects of the dragon-fly type, no inſect locomotion in the air. Air-locomotion relates to vacuums, and wind-preſſures the reſult of vacuums; and whether theſe vacuums ariſe from ſolar heats at the equator or ice at the poles, or both, producing winds, wind-preſſures, and bird-flying; or from the magazines of heat and force within the bodies of the inſects themſelves, producing winds, wind-preſſures, and Reactive Paſſive locomotion —the law is ſtill the ſame,—*vacuum-originated-force the fulcrum and foundation of air-locomotion*, for every living creature of the air, from the lady-bird that floats on a breath to the eagle that floats on a blaſt.

The bird-world holds a monopoly of the vacuum forces of the firmament; the inſect-world *(typified in the dragon-fly)* rely upon the forces created by themſelves. It remains for man to imitate the inſect, regarded as an animated fan-blower; but by no ſuch clumſy imitations as thoſe with which he has attempted to imitate wings. The mechanical fan-blowers contrived by man are not to be compared with the mechanical fan-blowers contrived by man's Creator. The material to be dealt with is *air;*

800 times lighter than *water*, and 6,400 times lighter than *iron*. Other things being equal, the reſiſtance of a fluid to the ſurface that oppoſes it is proportioned to the relationſhip between the ſpecific gravities of the two, for juſt as many times heavier as is the oppoſing body or ſurface than the fluid to which it is oppoſed, to this extent will it cut into inſtead of being reſiſted by the fluid. I am aware that it may be replied to this, that when air is driven at the high velocity employed in fan-blowers the fluid becomes practically ſo denſe as to admit of being dealt with the ſame as water. Very true as far as it goes. But why uſe up the power required to bring it to this denſity? Why not employ leſs power, and deal with the fluid as it is naturally? This is what the dragon-fly and inſects typified by the dragon-fly do.

The wings of inſects are perfect goſſamer, ſtronger and finer than the fineſt and lighteſt of fabrics that man can weave or make. From under the horny coat of mail which the beetle opens, ſee what a marvellouſly tranſparent tiſſue is unfolded to the breeze. From its crumpled condition one wouldn't imagine it wings. And the wings of the birds, what miracles of ſtrength and lightneſs! But why the body heavy and wings light? The body is to cleave the air, the wings to oppoſe it.

But man makes the wings of his fan-blower of *metal*—thin metal, it is true, but metal, nevertheleſs—in ſpecific gravity 6,400 times heavier than air! The contrivance is naturally like a rotary pump, and works centrifugally within a box: the conſtruction producing friction, waſte of power, and coſt.

Now turn from this picture and look at the little live blowers made by the Creator. As I have already ſaid, bees ventilate their hives by the action of their wings, a number of bees being for this work ſtationed in the paſſages and at the entrances to the hives: thoſe at the doorways holding faſt by their feet, to prevent being blown away by the wind-blaſts of their own wings.

Now here we have before our eyes the example of natural fan-blowers, without boxing, not working centrifugally, producing perfect blaſts of wind in the open air, to which they can give any direction they chooſe! What machine of this ſort has man ever conſtructed comparable to this? The moſt remarkable thing that happened in the courſe of my obſervations, was when I diſcovered that wings flapped at right angles to the body of the creature produced an air-blaſt, the *whole* of which was directed *backwards!* This mechanical puzzle I one day had the opportunity of finding out for myſelf. A large moth or miller, about the ſize of a bumble bee, finding itſelf in my room, and unable to get out, naturally took to where the light was ſtrongeſt—the window; but the window was cloſed; and my attention was attracted by the frantic efforts made by the creature in its attempts to force a paſſage by butting its head violently againſt the pane.

Hearing a great flutter of wings, and perceiving the cauſe, I ran for a lighted candle, which I held firſt at the ſides, at about three inches diſtance, when no flicker of the flame took place; neither did it at any point as I ſteadily moved the candle towards the rear of the creature, until I had it directly in line with its body exactly *behind it*, when the flame, with no premonition whatever, was puffed ſo ſuddenly out as to amaze me. I repeated this experiment ſeveral times over, and became then ſatisfied of what I had before ſurmiſed as to the action of the wings of flying creatures—viz., that as a *firſt* effect of wing-action, where the motion of the wings is at right angles to the body, a current of air is produced in the line of the long axis of the body; this *floats* it: the after effect, by a continuance of the wing movements, being *propulſion*, the wings then getting a fulcrum upon air of practically increaſed denſity. Later on I became convinced of the theory I have herein endeavoured to ſet forth, viz., that all the inſects typified in the dragon-fly move through the air by *indirect*, in place of *direct*, action: in other words, they employ their wings purely in their capacity of fan-blowers and not propellers, the only kind of air-locomotion poſſible to man: my reaſon for this opinion being, that a *flotation and impulſion* (not pro-pulſion) reſulting purely and ſimply from wind-blaſts, admits of the application of the *rotary* principle of mechanical power; ſo that all we have to do is to contrive an improved fan-blower, and, on the ſuppoſition that we are ſhortly to have a light motor, the air may be as ſafely navigated as water. I have myſelf contrived a *Fanning-wheel* that, to ſay the leaſt, gives good promiſe. This wheel is ſimply a hub furniſhed with wings made after the pattern wings of the dragon-fly; the revolution of the wheel *in open air* producing a powerful wind-blaſt *backwards*. Now it ſeems to me that a number of ſuch wheels, attached to a proper veſſel, would in ſome degree reſemble what is to be found in the inſect world as repreſented by the dragon-fly.

In what follows I deſire to have it underſtood that by the term Bird-flying is meant reactive, *direct* locomotion; the kind practiſed by all flying creatures except the claſs typically repreſented in the dragon-fly: while by the term *Inſect*-flying is meant reactive, *indirect*, or *paſſive* locomotion; the kind practiſed by all flying creatures typified in the dragon-fly. Humming-birds being more than half inſect, and their mode of flight being wholly ſo, are to be regarded as included under this head.

I do not offer this as ſpeculation. I offer it as theory deduced from obſervation. Let him who doubts it go with me to Nature herſelf—come with me into the clover-fields—thick with round-tufted heads, the ſweeteſt of white and the juicieſt of pink, and honey bees over them all; the air golden and ſtill: not a breath; pulſing with its own quietude. Can there be anything more delightful than to lie down here and watch the movements of the bees? We may look at them as long as we like, they won't quit work becauſe it is "half-holiday." Bees are workers in the ſtricteſt ſenſe, and all their "combinations" are againſt idleneſs, not againſt work, not againſt ſociety. Men can't do better than ſtudy them, eſpecially "tradeſ-union" gentlemen. Bees don't combine to turn out poor work, and diſcourage the production of good.

But never mind human workers, here are better ones; let us look at them: watch this little fellow in yellow pluſh breeches, and ſee how daintily he lets himſelf down from the air upon the clover-head that hardly bends beneath his weight. He can't run over it quick enough, and it don't take him the millionth part of a ſecond to find out juſt where the ſweet is, and eſpecially where it is not, and then he is up and off. Did you ſee him jump? You couldn't, for he didn't jump at all. The ſparrow jumps, and the pigeon jumps, and the butterfly jumps;[1] but the bee *floats* itſelf from the clover-tops as ſoftly as the miſt-wreaths of the dewy morning float away from the hill-ſide. No ſoap-bubble, brilliant with ſwimming colours ſtolen from the rainbow, ever floated off from the bowl of a pipe with more charming gentleneſs and grace. And in theſe ſoft murmurs of the buſy bee, as you watch him ſettling, and riſing, and floating, and ſettling again—in theſe delicate flotations and undulations, and in the low, ſoft, murmuring tones you hear, like elfin muſic from under moſſy ſtones—in all this, I ſay, lies hidden and concealed the marvellous ſecret of the air; the ſecret for which man has ſo vainly ſearched, ſo vainly toiled, ſo vainly prayed for during all the life of man on earth!

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[1] I was very much aſtoniſhed one day while holding a butterfly on my finger to diſtinctly *feel* the preſſure of its tiny little feet as it jumped off into the air. Pettigrew ſays he could never detect it, but I did unmiſtakably.

But who would have thought to find it amid the clover and the bees? Is it any wonder that mankind have not found it before? They never thought of looking for it *here!* Nor would I, but for the *dragon-fly.*

Men are heavy, heavier by far than birds, and if we knew of any flying creatures ſtill heavier we ſhould naturally paſs by the birds. Naturally, in our attempts to ſolve the problem of lifting and floating heavy weights in the air, we ſhould make the heavieſt flying creatures our ſtudy. This would be reaſonable, and "*reaſon.*" But to go to the *inſect* to find the ſolution of *ſuch* a problem is not reaſonable, nor "reaſon;" it is ſomething leſs or—*ſomething more!*

The movements of the dragon-fly diſplay majeſty and power, thoſe of the bee gentleneſs and grace. Let us now conſider a more humble member of the ſame family: the fly that can *ſtand ſtill in the air!* Houſe-flies almoſt do it, but this little creature does it to perfection. It is a ſpecies of fly to be ſeen in the country about farms, not larger than the common houſe-fly, but having longer wings; the colour of its body golden-green. A bevy of theſe little creatures when flying ſeem like a play of golden balls or little gilded peas floating in the air; their wings vibrate with ſuch ſwiftneſs as to be perceptible only as a *blurr* about them, 300 beats in a ſecond, 18,000 beats a minute! The fan-blower is conſidered to revolve rapidly at 3,000 a minute, a much eaſier mode, too, of fanning the air. If we wait a moment we ſhall ſee one of them ſtanding ſtill. Ah! here he is, ſtanding as ſtill as poſſible. You can't ſee a movement, and yet there muſt be ſome ſort of imperceptible vibrations reaching your eye from it, for it makes you feel as you look ſteadily at it as though in a dream. How in the world does the creature ſtand ſo ſtill? A dead fly glued to the wall couldn't be more fixed. Perhaps he has found an air-ſtratum of exactly the ſpecific gravity of his own little body. No, for now he ſuddenly darts to a place higher up, and fixes himſelf there again; and again to another ſpot, fixing himſelf juſt where he likes. Does Mr. Pettigrew's "figure of 8" theory explain this? or the theories of "pawing the air," or "compreſſing the air under the wings?" or "attacking the air at an infinite variety of angles?" Or is it to be explained by "the great range of motion of the wings, enabling them to convert large tracts of air into ſupporting areas?" Or has Mr. Pettigrew explained it where he ſpeaks of the multiplicity of the movements of natural wings, thus enabling the pinions "*to create and riſe upon currents of* *their own forming?*" Very nearly, Mr. Pettigrew, very nearly, but not quite! In the children's play of "hide and ſeek," even "burning" is not always "finding."

No bird-principle of locomotion in the air can explain the wonderful movements of the dragon-fly. Where the denſity of the fluid is ſuch as to furniſh the creature with a fulcrum almoſt or quite complete in itſelf, as in the caſe of water and the darting through it of ſpeckled trout, locomotion reſulting from direct action can be underſtood and admitted; but where, as the preliminary to a locomotion that depends upon *a conſtant and continuous creation* of force-denſity, flying creatures exhibit the darting movements of the dragon-fly and the floating movements of the bee, and over and above all the ſtanding-ſtill-in-the-air performance of the fly, nothing ſhort of the indirect locomotion reſulting from ſuperinduced wind-preſſures ſeems to be ſufficient to account for them. All the flying machines ever made by man have failed, and theſe have all been direct action or propelling machines. Why not now try the oppoſite (do it the other way), and ſee what can be accompliſhed by confining the whole of the power and all the fanning action of the machine to the work of *communicating force to the air?* When this machine fails, ſhould ſuch be the caſe, we ſhall have then, I fear, exhauſted the mechanical methods of getting through the air, and will be compelled to await further developments in electrical ſcience. Nearly forty years ago a gentleman remarked in my hearing that it was his belief that the flotation of birds in the air was due to an electrical *aura*, generated by the bird at will, producing a repulſion between the floating bird and the earth. And Profeſſor Page, a diſtinguiſhed American electrician and inventor, of Waſhington, D.C. (now deceaſed), once deſcribed to me the floating of a large bar of iron, weighing ſeveral hundred pounds, within the helix of his great battery, the profeſſor laughingly remarking that it was like Mahomet's coffin, ſuſpended between heaven and earth.[1] But I do not believe we ſhall be driven to this. My faith in the dragon-fly is ſtrong. The locomotion of every flying creature is, I am perſuaded, purely mechanical; and the man who firſt conſtructs a dragon-fly navigator of the air will beſtow upon mankind the long-coveted "ſeſame"—the magic key to all the treaſure-caverns of the ſky! and, I was about adding, will be bleſſed by all mankind. But when I think of earth's benefactors, and what has happened to them all, or nearly all, I forbear. I forbear alſo as I think of what may happen to us when this amazing faculty ſhall become the property and poſſeſſion of human devils! Think of floating devils in the air! Floating here and floating there; always floating; everywhere! filling mortals with deſpair! Crawling devils on the ground can do miſchief enough, and are hard enough to be trampled out, but in the air, one ſhudders to think of it! Still, God rules, and the air can't be navigated until He permits it; and whenever this time ſhall come we may be certain that all the contingencies attending it will be provided for by His wiſdom and goodneſs.

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[1] *Query?* May not cyclones or whirlwinds be *electrical helices*, capable of being rendered harmleſs by means analogous to Franklin's method of taming the lightnings?

The ſuction-pipe that pulled the workman's hat off his head, led ſtraight to the vortex or vacuum centre of the fan-blower. But the bee and the fly by the reciprocating action of their wings do better work in the open air. To uſe up in their operations as much power proportionately as man's fan-blower contrivance, would be a greater drain upon Nature's forces than ſhe ever permits. The moving creatures of the deep, and the moving creatures of the air, have power given to them in proportion to their needs, and each one an apparatus ſo perfectly adapted to its power, that while nothing is wanting there is nothing to be thrown away. Waſte marks the imperfect works of man: Economy the perfect work of God!

CHAPTER II.

Bird-Flying.

AS I have already obſerved, the ſpeculations and experiments of both ancient and modern times have all had reference to birds, and if inſects have received any attention, it has been becauſe no difference was perceived between their mode of air-locomotion and the flying of birds.

Cavallo, in his diſcurſive way, tells us of what fable and ſtory mention—"the winged horſes of the ſun," "Juno's peacocks," "Medea's dragons," "the pigeon of Archytas," &c., and that Roger Bacon, who lived in the thirteenth century, ſpeaks in his writings of "artificial wings that may beat the air like a *bird* flying;" alſo that the invention, ſaid to have been made by John Muller of Nuremberg, commonly called Regiomontanus, and who died in 1436, is deſcribed as a flying "eagle." It is alſo evident that Biſhop Wilkins, who wrote on flying in the fifteenth century, refers to *birds* in all that he ſays in his "diſcourſes on flying;" and "the alleged invention of the Portugueſe friar, Bartholomew Laurence de Guſman, made in 1709, was a veſſel ſomewhat in the ſhape of a *bird*."

But though all the attempts at flying recorded in hiſtory, or which we know anything about of later times and recent years, have been utter failures, the bird continues to be the ideal flying model of mankind; and "kites" and "inclined planes" are ſpoken of by inventors in all lands as confidently to-day as though the experiment had not been a demonſtrated failure through all the ages.

With the exception of ſome few ardent ballooniſts who ſtill appear determined to be original beyond Nature, the world in general have agreed that travelling through the air in balloons can never rank with ordinary locomotion on the land and water, and is therefore practically of no account to mankind as a mode of travel.

The next error to be got rid of is the notion *of flying*; of courſe I mean bird-flying; for the eſſence of bird-flying is *projectile force* and *live* wings, two elements or conditions utterly impoſſible for man; conditions that directly relate to the tremendous atmoſpheric forces of Nature, to meet which the bird is ſpecially organized, and with which it is able to cope; energies and forces in the midſt of which, floated and wafted upon dead planes only, men would be as helpleſs and hopeleſs as a loſt wretch in the rapids that lead to Niagara's thunders of waters.

As bird-flying relates to natural winds or the forces of the atmoſphere, let us for a moment, before going any further, conſider the nature and properties of the air.

"If we ſuppoſe the atmoſphere, (remarks Dr. Lardner,) which extends from the ſurface of the earth upwards to a height more or leſs conſiderable, to conſiſt of a ſeries of layers or ſtrata, placed one above the other, it is evident that each ſucceſſive ſtratum, in aſcending, will ſuſtain a weight *leſs* than thoſe below it. The firſt ſtratum of atmoſphere, which is in immediate contact with the ſurface of the earth, is compreſſed by the entire weight of the atmoſphere above it; that is to ſay, by the weight of the whole atmoſphere, except the firſt ſtratum; the next ſtratum is compreſſed by the weight of the whole atmoſphere except that of the firſt two ſtrata; the third ſtratum is compreſſed by the weight of the whole atmoſphere, except the firſt three ſtrata; and ſo on. Now, it has been already ſhown that the denſity of air is always proportional to the force which compreſſes it; and it follows, therefore, that the denſity of the firſt, or loweſt ſtratum, is greater than the denſity of the ſecond; and the denſity of the ſecond greater than the denſity of the third; and ſo on; the air becoming gradually leſs denſe as it aſcends to a greater height." * * * * * "The weight of mercury is 13½ times greater than that of water, and the weight of water is about 800 times that of air, at the mean denſity of the latter; conſequently, the weight of mercury is, bulk for bulk, 10,800 times greater than the weight of air: therefore a column of air of uniform denſity equal in weight to the barometric column, would be 10,800 times higher. Now taking the average height of the barometric column at 2½ feet, a column of air of equal weight, and having a uniform denſity equal to that of air at the ſurface of the earth, would give a height of 27,000 feet; and, ſince the barometric column is ſubject to irregular variations, which range within a twelfth of its entire height, the correſponding column of air would be ſubject to like variations, ranging within a like proportion of its entire height, which according to this calculation would amount to 2,250 feet. If, therefore, the atmoſphere were, like the ocean, of uniform denſity, *the height of the waves*, which would be incidental to its ſurface agitated by the diſturbances to which it is expoſed would be *nearly half a mile.*—But as the atmoſphere is not of uniform denſity, but diminiſhes in denſity in a rapid proportion, as the height increaſes, its altitude is much greater than 27,000 feet; and the change incidental to its ſuperficial level indicated by the variations of the barometer muſt therefore be proportionately greater. *The waves of the ſea, therefore, even in the moſt violent ſtorms, are abſolutely inſignificant compared with the waves which prevail in the upper ſurface of the ocean of atmoſphere under which we live!!*" See "Lardner's Philoſophy," book v., chap. 3. The italics and exclamation points are my own.

It is very eaſy to perceive from the above how vaſtly different are the conditions of bird-flying in our air-ocean from that of fiſh flying or ſwimming in the ocean of the waters; currents in the ſea are not comparable in force to currents in the air. Imagine human beings organized to breathe water like fiſhes living on the mountain ſlopes and in the valleys upon which the water-ſphere reſts, as upon us reſts the vapour-ſphere that inveſts our globe. All the living moving creatures we ſee about us at the bottom of our air-ocean, reproduced under the waters, and living upon the land there juſt as we live here; for the land upon which the ocean reſts is juſt as diverſified and real as the land upon which air reſts; once, indeed, above the waters and in the air, as we now are; and deſtined again to be, when our hill-ſlopes, plains, and mountains become again ſubmerged and form the bottom of the ſea. And the ſame Almighty Power that has faſhioned men and women and living creatures on the land above water to breathe the mixture of fluid nitrogen and fluid oxygen we call *air*, could have equally faſhioned men and women and living creatures for breathing the mixture of fluid hydrogen and fluid oxygen we call *water*.

And now if we imagine ſuch a living world as this exiſting underneath the ſuperincumbent water-ſphere; a living, active, buſy world; tribes, communities, and peoples: villages, towns, and cities: and if then to this picture we add to the water-ſphere the diſtinguiſhing characteriſtic that marks our own—its fickleneſs, its variability, its cyclones of terrific force—water-winds of all degrees: water-winds at ſeven miles an hour; water-ſtorms at thirty-ſix miles an hour: water-hurricanes at eighty miles an hour;—what a precarious world for the water people and creatures to live in! Howling water forces raging through the deep of waters as the wild forces of the air hold high carnival beneath our ſkies! Under a condition of things like this, no living creature poſſeſſed of any ſpecific gravity known to man could exiſt. A ſmall fiſh would require to be the weight of an elephant: it could float only by mechanical flotation; and the foundations of the mightieſt iſlands and continents of our globe would be in perpetual danger of being undermined and ſhattered to fragments. Imagine what would have to be the ſpecific gravity of the water-breathing creatures there, the men and the women. To be able to move about and cleave the waters with the ſame facility that our bodies move and cut through the air, would require a ſpecific gravity eight hundred times heavier than water, as our bodies in our atmoſphere are eight hundred times heavier than air. Under the preſſure of our atmoſphere it is a very light individual that weighs only 100 lbs: but multiplied by eight hundred it becomes 80,000, or forty tons! and a lady of 200 lbs. weight in London above the water, would be a lady of eighty tons weight in the ſubaqueous London at the bottom of the sea!

Let not this be conſidered a mere piece of extravagant imagination. The atmoſpheric ocean in which flying creatures float, and through which not only flying but all other creatures move, demands, becauſe of its forceful character, ſpecific gravities in the creatures of a character analogous to what I have supposed would be the required weight and ſpecific gravity of water-breathing creatures inhabiting a water-ſphere penetrated with the tremendous forces that are ſtored up and diſcharged continually through all the ſpaces underneath our ſkies.

The difficulties of air-locomotion do not inhere in the non-force character of the air in its eight hundred times leſs denſity than water, and the ſpecific gravity of the bodies of the creatures that live in it; but in the force-atmoſphere that ſurrounds them.

It is not, therefore, practically ſpeaking, the air that is eight hundred times lighter than man's weight and birds' weight (I admit ſomething leſs for birds) that we have to deal with in the problem of bird-flying, but the *Force-Atmoſphere* encloſed, ſo to ſpeak, within the atmoſphere we breathe.

This force-atmoſphere is the bird-atmoſphere, for which the creature is made and adapted, with reference to which his marvellous wings are made *light*, and his body made *heavy;* a body *to ſink* it, and wings *to raiſe* it; two oppoſing agents giving rise to two oppoſing forces: the one a counteracting agent to the other, and yet conſpiring to a common end; a mechaniſm and a combination of forces to meet and battle with, and over-come, and make ſubſervient the forces of the air, only to be conceived of in the previſion of an Infinite Mind, and only poſſible to the ſuperviſing and all-governing intelligence of a Great Firſt Cauſe. Surely if an undevout aſtronomer is mad, he is ſtill madder, who, with God's marvellous creations all around him can fail to ſee, or ſeeing, can deny the Exiſtence and the Perſonality of God!

In this force-atmoſphere velocity is equivalent to denſity, and ſtands for it. It is the force of the air-current, whether cauſed by the wings of the flying creature, or exiſting naturally in the force-atmoſphere, that gives the reſiſtance of flotation and the reſiſtance of locomotion.

On land the reſiſtance, which is ſupport, is at the ſame time, the fulcrum of locomotion; both functions in ſolids being a co-exiſting unit.

But in fluids, where the ſupport or flotation reſults from diſplacement, the reſiſtance which conſtitutes flotation precedes, in ſequential order, the reſiſtance which conſtitutes the fulcrum of locomotion. The fulcrums are, therefore, *two*: a fulcrum of ſupport or flotation, and a fulcrum of propulſion or locomotion.

But for the forces of the atmoſphere, hydrogen ſhips might float and be propelled in it equally as well as ſhips are on the ocean. A balloon made in the ſhape of a fiſh ſhould float perfectly in ſtill air, and admit of propulſion in ſuch an atmoſphere as ſhips do in water. Whales are the balloons of the ſeas; lighter than the waters of the ocean, on the ſurface of which they float, to navigate it were as impoſſible to them as are the ſtretches of the air to veſſels floated by hydrogen were the deep charged with water-forces of analogous character to thoſe that fill our atmoſphere.

The problem of air-locomotion is, therefore, one of FORCE; and bird-flying can only become poſſible to man when men are changed to birds.

If we regard the wings of birds in their primary capacity of fan-blowers for creating air-currents to fly in, then the longer the wing the ſtronger the current of air, and the greater the volume of it when produced by the wings. For example, let us ſuppoſe the wings when deſcribing a complete circle to ſet an air-current in motion of a diameter equal to the ſtretch of the wings from tip to tip. Wings then meaſuring two feet from tip to tip ſhould create an air-column four times as great as wings meaſuring but one foot from tip to tip; and wings meaſuring three feet from tip to tip ſhould create an air-current or column nine times as great as wings meaſuring but one foot from tip to tip; and wings meaſuring four feet from tip to tip ſhould create an air-current or column ſixteen times as great as wings meaſuring but one foot from tip to tip; and ſo on by ſquares. The long axis of the bird being practically the axis of the air-column created by the wings.

So that when large and heavy birds are ſeen, as Captain Hutton deſcribes the albatroſs, whoſe wings meaſure fourteen feet from tip to tip, "ſailing and wheeling about in all directions for more than an hour without the ſlighteſt movement of the wings," we are to conclude that the ſtrength or force-denſity exiſting in the winds that float the bird is equal to what the wings of the bird indicate to be its ability to create did neceſſity require it.

In illuſtration of the power of wings in rapid vibration to produce flotation, let us for a moment conſider the law of atmoſpheric reſiſtance to moving bodies. I quote again from Lardner:—

"*Reſiſtance of the air to the motion of falling bodies.*—It has been ſhown that a body obedient to the action of gravity would deſcend in a vertical line with a uniformly accelerated motion. Its velocity would increaſe in proportion to the time of its fall, ſo that in ten ſeconds it would acquire ten times the velocity which it acquired in one ſecond; but theſe concluſions have been obtained on the ſuppoſition that no mechanical agent acts upon the body, ſave gravity itſelf. If, however, the body fall through the atmoſphere, which in practice it muſt always do, it encounters a reſiſtance which augments with the ſquare of the velocity. Now, as the accelerating force of gravity does not increaſe, while the reſiſtance continually increaſes, this reſiſtance, if the motion be continued, muſt at length become equal to the gravitation of the falling body; and, when it does, the velocity of the falling body will ceaſe to increaſe. It follows, therefore, that when a body falls through the atmoſphere, its rate of acceleration is continually diminiſhed; and there is a limit beyond which the velocity of its fall cannot increaſe; this limit being determined by that velocity at which the reſiſting force of the air will become equivalent to the gravity of the body.

" As the reſiſting force of the air, other things being the ſame, increaſes with the magnitude of the ſurface preſented in the direction of the motion, it is evidently poſſible ſo to adapt the ſhape of the falling body, that any required limit may be impreſſed upon the velocity of its deſcent. It is upon this principle that parachutes have been conſtructed.

" When a body attached to a parachute is diſengaged from a balloon, its deſcent is at first accelerated, but very ſoon becomes uniform, and as it approaches the earth, the air becoming more and more denſe, the reſiſtance on that account increaſes, and the fall becomes ſtill more retarded." —LARDNER'S *Natural Philoſophy*, book iii. chap. 9.

It is manifeſt, without argument, that an aſcenſional current of air eſtabliſhed underneath the parachute, with a force equivalent to the fall of the body, would have the ſame retarding effect as the deſcent of the parachute through the air: alſo that an increaſe of the aſcenſional force beyond this point would ſupport the parachute in oppoſition to the force of gravitation, and eſtabliſh a fulcrum of locomotion.

The wings of a bird are its parachutes; and the *movements* of its wings *the fall* of the parachute, but *lifted* as faſt as they fall; and as the *reſiſtance* occaſioned by the fall (wing motions) *augments with the ſquare of the velocity*, the wings have this in their favour.

And although the heavieſt bird that flies is, for its protection and ſafety, gifted like the inſect with the power of riſing in ſtill or forceleſs air from the ſurface of the ground, or from the face of the waters, its home, nevertheleſs, is in the air, where its neſt is among mountain peaks, or inacceſſible hill-ſides, or on the tops of trees, in the ſpires of churches; or under the eaves of houſes, from whence the creatures launch themſelves, and on their parachute wings ſail and ſkim through the air by a projectile-force flotation due to their weight employed as force.

Pettigrew ſpeaking to this, ſays: "The flying animal receives ſupport from the air by increaſing the ſize of its travelling ſurfaces. * * * When an inſect, a bat, or a bird is launched in ſpace, its weight (from the tendency of all bodies to fall vertically downwards) preſſes upon the inclined planes or kites formed by the wings, in ſuch a manner as to become converted directly into a *propelling*, and indirectly into a *buoying*, or ſupporting power." (See Pettigrew's "Animal Locomotion.") If, inſtead of *inſect*, Pettigrew had ſaid *butterfly*, he would have been more correct.

Any one who watches birds, eſpecially large ones, will diſcover that their flying conſiſts mainly of ſailing. The weight of the bird's body that impels it down the inclined plane of the ſky ſends it up again by the momentum thus acquired, aided generally by a few vigorous ſtrokes of its wings; and the ruſh of the wing-ſurface of the bird *over* the air-ſpaces it traverſes, amounts practically to the ſame thing as a wind or air-current ruſhing *under* the bird. Swallows are ſplendid examples of projectile-force flying; the momentum acquired in their flight enabling them oftentimes to riſe perpendicularly for ſeveral feet; the ſhape of the bird, and its wings, being for this mode of flight marvellouſly adapted. Its power too, to increaſe or leſſen the tendency of its body to fall, by the opening and cloſing of its wings and tail is wonderful; its movements in doing this are like flaſhes of lightning. What the ſwallow is able to perform in ſtill air, by the celerity of its movements on ſmall wings, the albatroſs, the condor, and the eagle accompliſh amid powerful wind-forces with their greater weight and ſpread of wings by ſlow and eaſily ſuſtained movements and at almoſt no expenditure of their motive-power.

No better illuſtration than the following can be given of the uſe made by birds of the force-denſity of the atmoſphere, and of its neceſſity to them under certain conditions.

When a flock of geeſe, feeding on the commons (a cuſtomary thing in New England, U.S.A.) feel an inclination to fly, they prefer to wait for the riſing of a good ſtiff breeze; the weight of the creatures being uncomfortably great in compariſon to their motive-power. When the breeze is at its beſt, the geeſe ſet up a tremendous quacking, ſtretch out their great wings to the utmoſt, elevate their heads, and bring their wing-planes well up towards the perpendicular; they then ruſh againſt the wind as hard as they can, at the ſame inſtant beating the air violently with their wings. The effect is quite magical:

The whole flock in a ſecond are off their legs, afloat, and away on the air.

But, as a rule, birds are ſufficiently light, and have ſpring enough in their legs, to leap into the air and find immediate flotation. A crow, as it hops along the ground, ſeems to almoſt float as it hops; and the delicate and gentle manner in which it lowers itſelf upon a ſlender bough at the top of a tall tree when ſettling itſelf for the night is delicious to behold. The amount of motive-power ſtored up in the tiſſues of the creature's great wings muſt be immenſe.

One is ſtrongly impreſſed with the infinitude of Nature's reſources when conſidering the great variety of method and movement with which the creatures of the air are gifted. One ſet of creatures, with *weight* as an element of their organization, are conſtructed with wings of variable lengths and proportionate breadths with reference to their habits and modes of exiſtence, and with inſtincts that lead them to ſelect for their habitations ſituations that, in their firſt efforts to fly, precipitate them into ſpace, thus calling into immediate requiſition the weight-function of their organiſms, the reſult being *projectile-force* locomotion. Again, we have the creature *entirely* ſupported on the winds. Then we find a *combination* of wind-ſupport and projectile-force flotation. Under another modification, the bird, by a ſort of rudder-principle, ſails with and upon the wind, being carried along and floated by its force.. By another mode, the bird, floated in the force-atmoſphere, as a veſſel is floated on water, *propels* itſelf in ſubſtantially the ſame manner as fiſhes propel themſelves; or the bird *combines* projectile-force flotation with wing-propulſion; or the bird ſubmits itſelf meekly to the wind-forces of the air, and ſetting up *a paſſive reſiſtance* (as individuals and governments ſometimes do), conquers the forces of Nature, and *compels the winds* to move it forward upon a pathway ſelected by itſelf and upon which it deſires to travel! a miracle of locomotion in the air poſſible only to *a bird.* To this we may add the flying of bats and butterflies, or animated parachutes, and, to crown all, *the Dragon-fly, or Reactive-Paſſive Locomotion!*

Under ſuch circumſtances, is it to be wondered at that the ſecret of aerial locomotion has for ſo long a time eluded the graſp of man?

There was a time when inventors, or ſome of them at leaſt, thought it neceſſary to exactly imitate Nature in order to follow her, and with this view condemned *wheels* and argued for *legs* and *feet* inſtead, not perceiving that the ſpokes of the wheel are the legs, and the periphery the feet: the difference between the methods being that in one the fulcrum of ſupport and locomotion is intermittent and in the other continuous.

In the ſame way, mankind have imitated Nature and conſtructed *wings*—wings "to *beat* the air as a bird when flying." And, where they have attempted ſomething different, it has been a device poſſeſſing no *wing*-function whatever, a "*helice*" or *ſcrew*; the effect of which, I admit, is bird-flying, but of the *projectile* locomotion kind, far better, certainly, and more ſenſible, than "aero-planes" or any flat planes, and *nearer* to dragon-fly locomotion, for it introduces *ſmall ſurfaces and high velocities* in place of extended ſurfaces with relatively ſlow movements. In this view it is an approach in the right direction, and the reſults obtained by Nadar and Landelle at one time ſeemed quite encouraging. In my opinion they would actually have ſucceeded had they been fortunate in the poſſeſſion of a true theory, for they would then have made a *fanning-wheel* inſtead of a *helice*.

With regard to the helice or ſcrew, I ſhall have ſomething to ſay in the Appendix. In this place I content myſelf with merely remarking that in my view the ſcrew is *a miſtake*, whether in *water* or air.

I come now to what, for want of ſome better way of expreſſing it, I have ventured to call *paſſive* locomotion. And to this I aſk the reader's ſpecial attention. It is the paſſive locomotion of birds in the air, the moſt intereſting ſight, and, in the abſence of a clear perception of what flying actually conſiſts in, the moſt extraordinary poſſible to conceive of, ſo very extraordinary that even Profeſſor Marey only admits it as a fact becauſe of the teſtimony of the many who have witneſſed it. My motive for aſking the reader's ſpecial attention to this is becauſe of the uſe I intend to make of it in illuſtration of the poſition I have aſſumed with reſpect to the reactive indirect or paſſive locomotion of the dragon-fly and creatures of its claſs.

The Atlantic voyager who cares more to watch the birds than his ſegar as he walks the deck of his ſteamer, will obſerve, as he approaches the Britiſh coaſt, immenſe numbers of ſea-gulls, of apparently all ages and ſizes, following in the wake of the ſhip: ſome wheeling upwards, ſome diving downwards; at one moment miles ahead; and at another moment, miles behind: a bevy of them always hovering near the ſtern of the veſſel, on the look-out for any ſtray bits from the ſhip's larder or ſtores that may be thrown overboard. At ſuch times nothing can exceed the dexterity of the creatures: the ſuddenneſs with which they precipitate themſelves upon the waters; the celerity with which they evade the billows; the accuracy with which they aim at the coveted morſel floating upon the dancing wave; and the graceful eaſe with which in circling flight they mount again into the air. And this,—not for an hour —not for hours—but *all day long*—a ſight calculated to intereſt any lover of Nature, but of eſpecial intereſt to one who at five years of age began his experiments in aerial locomotion, by attempts to *walk* upon the air. I felt quite ſure I could do it: nor was my faith weakened in the ſlighteſt degree by the conſtant failure that attended my efforts: nor has it ever weakened ſince:—what *ought* to be done *can* be done. And now, as I look back over a waſte of more than threeſcore years—that childiſh effort, in the light of my dragon-fly experience, and in the light of the great present—the ſteady advancement of the human mind—the marvels of ſcience—the onward march of men towards mighty goals —the Alpine peaks of man's aſcent towards God already climbed:—in the light, I ſay, and in view of all this—as I look back upon that infantile faith and effort, I cannot help regarding it in the light of a prophecy and an inſpiration! The ſcene is all before me now, I can ſee it to-day, as it took place ſixty-two years ago. The deſerted ſchool, ſcholars all gone home—(my father's ſchool)—a little child alone: alone with his own thoughts: and "the thoughts of a child, are long, long thoughts."—Yes, I felt ſure I could do it: and mounting one of the long benches, and walking quickly, I ſtepped from the end rapidly off into the air!—Nothing daunted or diſcouraged by the failure or the fall, I repeated the experiment with, "I *will* do it!" Again and again going over the ſame ground only to fail, and to fall as before, but with each ſucceeding failure only the more determined that I *would* do it; and only abandoning the efforts when the exhauſted muſcles and quivering nerves themſelves gave out. But Will and Faith are a mighty team: they ſcale mountains; carve out deſtinies; ſubdue deſerts; eſtabliſh highways of civilization and commerce through wilderneſſes before untrodden by the foot of man; and, armed with the torch of ſcience, ſcatter from the face of Nature the gathered darkneſs of ages and generations.[1] "Impoſſible" has no place in the vocabulary of Will and Faith. The preſent and the future, alike of the world that now is and of the world "that is to come," belong to Will and Faith. The Paſt—and Death—and Corruption—and Oblivion, belong to the faint-hearted and the faithleſs.

The locomotion of a bird in the air, which does nothing but hold itſelf with engineering ſkill amid the forces of the winds, and in performing this feat travels *pari paſſu* with a veſſel ſteaming at the rate of fifteen knots an hour, is ſomething worth ſeeing. I have ſeen it more than once.

The bird travels in face of the wind: the winds blowing ſtrong. The bird drawing in its wings and holding them partially cloſed eſtabliſhes itſelf in the air in a poſition where it leans ſlightly forward of a true perpendicular line: the wings and body together make a practically flat ſurface or inclined plane ſo set in the midſt of the wind-forces as to ſplit them, ſo to ſpeak, exactly on the line of cleavage, where the forces in front of the bird not only ſupport it againſt its tendency to fall, but at the ſame time *uphold* it as againſt the preſſure of the wind-forces at its back; the wind-preſſure againſt the back of the bird conſtituting an *impelling* force to produce locomotion—and the wind-preſſure againſt the front of the bird maintaining it in poſition to be driven forward—the path which it travels under theſe conditions being *perfectly horizontal.*

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[1] Stanley in Africa.

Like the wing-movements of the ſwallow, the wings of the gull may be ſeen to have a ſort of nervous twitching, as the creature, ever watchful of the ſtrength of the air-currents, increaſes or diminiſhes its wing-ſurface to increaſe or diminiſh the wind-force in relation to its falling weight. This feat of the gull, is, I think, the ſort of thing for imitation, that men ambitious of "flying" ſhould firſt undertake to do. It will be a *ſtatic* performance ſure to immortalize the man who does it.

CHAPTER III.

Insect or Reactive-Passive Locomotion.

IN his work on "Animal Locomotion," alluding to the ſpeed attained by inſects, Pettigrew obſerves as follows:—"Everyone when riding on a warm ſummer day muſt have been ſtruck with the cloud of flies which buzz about his horſe's ears, even when the animal is urged to its faſteſt paces: and it is no uncommon thing to ſee a bee or a waſp endeavouring to get in at the window of a railway-car in full motion. * * * If a ſmall inſect like a fly can outſtrip a race-horſe, *an inſect as large as a horſe would travel very much faſter than a cannon-ball.*"

He alſo remarks that Leuwenhoeck "relates a moſt exciting chaſe which he once beheld in a menagerie between a ſwallow and a dragon-fly (*Mordella*). The inſect flew with incredible ſpeed, and wheeled with ſuch addreſs that the ſwallow, notwithſtanding its utmoſt efforts, completely failed to overtake and capture it."

In the above extracts Pettigrew has borne unconſcious teſtimony to the importance of the inſect world in their relation to aerial navigation, and in a manner propheſied of its accompliſhment through their agency.

To the ſuperficial gaze of man, Nature frequently ſeems inconſiſtent; but harmony reigns through all the works of God. Seeing that the portion of the atmoſphere neareſt the earth has the greateſt denſity, being the loweſt of the air ſtrata, we ſhould naturally ſuppoſe it beſt fitted for the heavieſt of the flying creatures. Inſtead of this, we find the heavieſt birds neareſt the clouds, and inſects and the lighteſt of flying creatures neareſt the ground. But the reader who has followed me thus far will be under no loſs to account for this. Force, though viſiting the ſurface of the ground, and holding conſtant revels in the ſtratum neareſt the earth, dwells in the ſkies, deſpite the fabled Æolus, with caves on earth. And the birds, as we have ſeen, find inſtinctively the forces where they are.

But the inſect world of dragon-fly type are quite independent of the birds and bird methods of navigating the air: they are the poſſeſſors of an independent ſphere of their own. The winds of the firmament they neither court nor ſhun. Their locomotion goes on as well within the ſtifling atmoſphere of a chamber of "dead air" as in the open, where the breezes ſtir the flowers. No moſquito ever had one bite the leſs becauſe of the deadneſs of the air he was getting his repaſt in: no bee ever miſſed the ſip of a flower becauſe the winds were not blowing: and no waſp ever gathered leſs clay for his neſt, or ſtopped a minute's work for want of winds to fly on. Wind or no wind in the atmoſphere, the wings of the little buſy bee, and waſp, and fly make neither one beat leſs nor more; for the locomotion of all is due to the *impulſion* of the air-preſſures created by the fan-blowing action of their wings.

Let us now conſider the philoſophy of the fly that ſtood ſtill in the air. The little ſea-gull that I have deſcribed as travelling with our ſteamer by a ſort of paſſive locomotion—it ſhould be obſerved—invariably kept its poſition juſt above the ſhip, not moving one inch forward or backward. With reſpect to the ſhip, it ſtood as perfectly ſtill in the air as the little golden-green fly ſtood in the barn-yard.

Now then, here we have two *facts*. Let this be noted. In the caſe of the bird, the ſtanding-ſtill performance is clearly traceable to the force of the atmoſpheric winds in the firmament, winds having their origin outſide of, and independent of, the bird. In the caſe of the fly (when I ſaw it), *there were no winds in the atmoſphere.*

Now if we aſſume atmoſpheric conditions ſubſtantially alike in both caſes, and admit—as admit we muſt—that the wind-preſſures ſupporting the fly in ſpace are due to the play of its wings—the concluſion is irreſiſtible that the fly, when ſtanding ſtill, is as really ſuſtained by a balance of forces as the bird:—and its locomotion or darting movements are equally the reſult of wind-preſſures that cauſe a *paſſive* locomotion ſubſtantially the ſame with that of the bird.

But although the principle according to which the bird performs its feat in the air is the ſame with that of the fly, the modes vary. The art of the bird conſiſts in accommodating itſelf to wind-preſſures over which it has otherwiſe no control; but the inſect is maſter both of itſelf and the wind-forces it creates. The upright poſition of the bird and the folding of its wings do not neceſſarily exiſt in the performance of the inſect—though I may remark in paſſing that the houſe-fly, when ſtanding nearly ſtill in the air, holds its body in a manner approaching that of the gull, but not ſo upright.

The flapping of a bird's wings, at right angles to its body, produces, as I have ſaid, an air-current in volume and ſtrength proportioned to the ſtretch of the creature's wings and the rapidity of their movements: this air-current flowing from front to rear becauſe the flexible portions of the wings or fans *look to the rear*.

That a bird has the power to a conſiderable extent to change the poſition of the fans ſo as to make them fan the air ſomewhat differently, cannot be doubted. We ſee this when a pigeon, coming down in a hurry upon the ground, and wiſhing to break the fall, throws its head well up to the perpendicular, gets his body as plumb as poſſible, and with his wings ſtretched forwards and upwards and flapping them vigorouſly, produces a powerful down-blaſt of air, with the effect of creating a ſort of air-cuſhion to alight on. Anyone who will take the trouble to look at a pigeon may ſee this; the out-flying in all directions of the débris and duſt upon the face of the ground bearing ample teſtimony to the character of the wind-blaſt.

But the dragon-fly and all other inſects of its claſs are organized with ſpecial reference to the ſort of locomotion I have deſcribed as belonging peculiarly to them, viz.:—*paſſive locomotion.* To this end, they muſt be able to not only fan the air in *any and all directions*, but practically, *at the ſame inſtant of time.* Upon no other theory can I account for the ſtanding-ſtill-in-the-air performance of the fly in an atmoſphere unruffled by the ſlighteſt breeze—for the floating movements of the bee, or the backward and forward floating of the dragon-fly.

If then we aſſume for theſe inſects the poſſeſſion of ſuch a power, our reaſoning in attempting to explain the mode by which the fly ſtands ſtill in the air will be this: When, for example, the dragon-fly fans the air only backward, it moves forward; when it fans the air only forward, it moves backward; let both operations be performed ſimultaneouſly (and it has two pairs of wings), and it will ſtand perfectly ſtill, providing it ſo manages the preſſures as to produce forces that at the ſame time antagonize all tendency to upward and downward movement.

Now, whether the fly in queſtion is fortunate, like the dragon-fly, in the poſſeſſion of two pairs of wings, I can't ſay. If it performs the feat with only one pair, it is ſo much the ſmarter, and we muſt aſſume for it the wonderful power of being able, with its one pair of wings, turning in every direction (like the flaming ſword of the Cherubim in Eden), to produce practically a *hollow ſphere or vacuum centre* in the air, the ſpherical wall of which is compoſed of the wind-preſſures produced by the fanning action of the wings in their univerſal play, this vacuum centre having practically the effect of the *electric aura* ſome have imagined, and floating the creature as effectually as though encloſed within a ſphere of hydrogen or other gas capable of creating a ſpecific gravity of like denſity with the ſurrounding atmoſphere.

Upon this view of the caſe, it is eaſy to ſee that the dart-like locomotion of the barn-yard fly, like that of the dragon-fly, reſults from an unbalancing of forces; the forces weakened at any point in the ſpherical wall producing a preſſure at the oppoſite point of correſponding force.

If it be objected to this theory of aerial locomotion for man on the ground that it is contrary to Nature—ſeeing that bird-flying is the method of Nature for all creatures having ſubſtantial weight, and that the paſſive locomotion I have deſcribed has been confined by Nature to creatures poſſeſſed of practically no weight—I would call the attention of the objector to the fact that Nature, in organizing living creatures for our planet, has provided, not for locomotion alone, but for *all* the needs of the creature, its *mode* of locomotion has therefore reference to conditions that do not fall within the ſcope of our inquiries. The objection conſequently cannot properly be urged.

But my purpoſe is to neither anticipate objections nor anſwer them. Neither am I careful as to reſults. The object of this book is to introduce to the notice of my fellow-men a theory that may poſſibly lead to the reſult the world has wiſhed and waited for ſo long. At one time, and not very long ago either, I had hoped to do ſomething more than write-out theories. I had even gone ſo far as to conſtruct the fanning-wheel I have ſpoken of. But the field is too great for any one man. Aerial navigation demands earneſt work from many heads and many hands, and the beſt inventive talent of mankind will all be needed for its accompliſhment.

Should the theory I have attempted to unfold in theſe pages aid in any manner towards the accompliſhment of the great purpoſe, I ſhall feel amply repaid, and without other reward reſt contented in the ſatisfaction of a

DUTY PERFORMED.

NOTE.

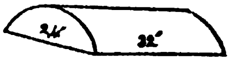
I HAD not yet recovered from long-continued illneſs at the time the following letter was written, and could therefore give no perſonal attention to the experiments alluded to. The letter relates to the fanning-wheel I have ſpoken of. The writer, Mr. A. P. Brown, of New York City, U.S.A., an ingenious mechanic, was employed by me to conſtruct and experiment with the wheel: and among other things, I had directed him to obſerve the lifting effect of the wind-blaſt upon a canopy or ſail: this is what he alludes to in one part of his letter. I quote the letter, as it may poſſibly intereſt some of thoſe whoſe attention, like my own, has been directed to this subject:—

"New York, January 20th, 1882.

"FRIEND H——,

* * * * "The wheel is of 3 fans—each 9½ inches by nearly 3 inches in the wideſt part. It is pulled by a cord wound on a crank-wheel, and gets 80 turns at once winding up. It got 90 with the smalleſt cord here encloſed" (about like ſhoemaker's thread), "but the cord broke. To get 80 turns of the 'fly,' 22 turns of the crank-wheel are required. Time conſumed is 10 ſeconds. So the velocity of the fly is 480 *per minute.*" (This don't amount to much in compariſon with the 18,000 of the real "fly!") "At and during 9 to 10 of the firſt turns the air draws *towards* the wheel from front *and rear alſo.* This means that the wheel rarefies the air in its immediate neighbourhood, paſſing it off radially to itſelf." (The little miller did far better than this.) "By the end of this time *ſufficient velocity* is attained *to ſet* the ſails *aſkew,* and *a backward current gets itſelf eſtabliſhed,* and continues with reaſonable and increaſing uniformity to the cloſe of the experiment." (This ſettles the queſtion of ROTARY wings, and proves my theory of *automatic adjuſtment* of the wing-fans by air-preſſure; and equally proves the applicability of the wheel, when conſtructed with properly organized *preſſure-blades,* to water as a propeller in lieu of the waſteful and imperfect "ſcrew" now in use.)

"The wheel only makes 1 to 2 revolutions at the utmoſt, after the cord is all wound off. There is a tendency in the air-current to ſhift it from ſide to ſide a little; perhaps the operator's arm or ſhoulder or head may cauſe it. There is alſo a noticeable ſide inclination to the current next to the wheel from left to right, and *vice verſa*, according to the direction in which the wheel is revolved (eaſily accounted for). The canopy, a dead flat, gave indifferent results at any angle and in all poſitions. A hood or bonnet 32″ long × 24″ wide gave better reſults and a maximum of effect when ⅓ of the 32″ was forward of the plane of revolution, and ⅔ to the rear. I alſo meaſured the angle carefully, having Fred" (the aſſiſtant) "get an independent verification thereof, and found it to be inclined above the horizon 34° (angle of ſcreen to the ſhaft 34°), and the back end of ſcreen 4″ below centre of ſhaft. At the 10th turn of the crank the ſcreen will riſe 4″ to 5″ (at back end), and remain there ſteadily during the run.



"All the lifting power we have yet been able to attain is 2⅓ to 3 oz.: current acting on this large curved ſcreen. As to the *power*, I ſend ſamples of the cords; the ſmalleſt of the three held well until ſomewhat worn.

"A. P. Brown."

P.S.—My friend Willis Gaylord, Eſq. (of Brooklyn, U.S.A.) has charged himſelf with the duty of "materializing" ſome of the *ideas* ſet forth in the pages of this book—*patents* being one of the "conditions."

So far as *Water* navigation is concerned, I am reconciled to this; but not as to *the Air*. If the theory of "Paſſive locomotion" herein ſet forth be the *baſis* needed by inventors, in order that mankind may realize their long-cheriſhed dreams, that baſis ſhould be free to all: more eſpecially in view of the unuſual incidents attending its promulgation to the world. Under theſe circumſtances I deſire to have it underſtood by all inventors, that, ſo far as regards *the new principle* of aerial navigation ſet forth in theſe pages—and the "fanning-wheel" deſcribed herein as a "reduction to practice" of the new principle—they are to be regarded as *the common property, and as being hereby dedicated to the ſervice of all mankind.*

T. H.

APPENDIX.

Water and Water Navigation.

I HAVE not croſſed the ocean as many times as Captain Lott, but I have been over it often enough to appreciate its majeſty and its beauty, its grandeur and the terror of its perils; and by a long and often repeated experience of it in all its moods, to realize by ſympathy the feelings of thoſe who periſh amid the ſeething of its raging billows.

And I remember the ill-fated "Preſident," the day that ſhe ſailed from New York, on the 11th March, 1841. We ſailed out together. I in the "Charlemagne," bound for New Orleans. And a pang of diſappointment paſſed through my heart, and I complained in my ſoul at the ways of Providence as I looked upon the beautiful ſteamer gaily decked in ſtreaming colours, and I longed by one leap to be on her and away to the grand old world ſhe was bound to. Yes, I murmured.

We ſailed out together, and the night ſoon came on, and a ſtorm, then a hurricane, ſo frightful that to me it ſeemed a carnival of all the wind-demons of the ſkies. When the morning broke we were toſſing about on the billows, and our captain with his glaſs ſighted the ſteamer in the diſtance labouring in the ſeas. "She is making no ſteam," remarked Captain Packard, gravely; and then, as the old man teleſcoped his glaſs, he ſaid, ſolemnly—"*She can't live; ſhe muſt go down!*" And the eye of our captain was in all probability the laſt mortal eye that looked upon the hapleſs, ill-fated "Preſident." She was never heard of more!

Twelve years later, in July, 1853, I ſailed for Europe in the Collins ſteamer "Pacific," returning in the "Arctic" (ſame line) in October. The ſame month of the year following, the "Arctic" went down off Cape Race with 360 ſouls on board. And ſix months afterwards the "Pacific," taking the "North'ard paſſage," ſteamed out from Liverpool into regions of darkneſs, where ſunlight never enters—and no man lived to tell the tale! And ſince then, how many more? Alas! how many?

And the winds and the waves ſtill conſpire againſt us, and the principle of flotation in ſhip-building remains to-day where Noah found it, and the Norſemen and the Vikings left it, and the ocean is ſtill ſtrewn with wrecks, and the deep is a graveyard ſtill! And the crape and the moans of the mourners, and the ſick hearts of the deſolate, and ſighs for the loved and the loſt, for the dead that ſhall never return! Alas, poor hearts!

If mechanical flotation be poſſible in air, why not in water? If water reptiles, the cruſtacea, and fiſhes can float themſelves by mechanical means, why not veſſels that are propelled by ſteam? Would it be any harder to propel the ſteamer towards the ſky than ſtraight ahead? And if there were propellers enough about the boat, and the right kind of propellers, and fixed in the right places about the ſhip, and connected with the ſteam-engine in the right way, and placed at the proper angle to propel towards the ſky, wouldn't they lift the ſhip, and couldn't this lifting power be made ſo great as to keep the veſſel from going down even though leaking and full of water?

If it could be done, we might ſtop making a graveyard of the ocean. Why can't it be?

All the water-creatures that are lighter than water are under juſt as much neceſſity of employing mechanical force to travel down through the waters, as the heavier ones are to travel up: ſo it ſeems to come to about the ſame thing for both of them. Getting through the water is a mechanical matter any way; and it takes no more force apparently to make the heavy creatures float than it does to make the light creatures sink.

Why, then, can't we have Mechanical Flotation for Steamſhips?

I am afraid there are a great many people yet who can't give up the balloon principle for water-flotation any more than ſome others can't give it up for air-flotation. And the former of theſe good people believe to-day as firmly in the pretty legend of the "ſwim-bladder" to float the fiſh up through the waters as the latter do in "heated air cells" and "hollow bones filled with air" to make the birds light enough to fly! And yet there isn't anything in nature to warrant one more than the other.

Locomotion (including flotation) in the water is juſt as purely a mechanical affair as locomotion in the air and on the land.

And the hiſtory of all water-animals proves what I ſay.[1]

And if it requires no more motive-power to produce flotation than propulſion, why can we not employ the power of the Steam-Engine of Steamſhips to create Mechanical Flotation and prevent the veſſel from ſinking, no matter how leaky or how far diſtant from land?

And ſtop making a graveyard of the Deep!

It iſn't an agreeable ſenſation to be on board a ſteamer in mid ocean and have ſomething happen. It makes you feel badly enough when it's nothing more than the veſſel coming to a ſudden ſtop—and nobody knows why—and all the officers of the ſhip are ſuddenly ſeized with the majeſty of a great dignity and the ſolemnity of a myſterious ſilence; and all the paſſengers at the dinner-table lay down their knives and forks, ſuddenly loſe their appetites, and begin to look into each other's faces; and a few benevolent and courageous gentlemen (determined not to be left) ruſh upſtairs to find out the news, and come back and tell you all about it: and the ladies at the table don't laugh any more, and white lilies bloom faſter in pale cheeks than common. Ah! theſe are ſenſations!

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[1] "The otaria or ſea-bear," ſays Pettigrew, "ſwims, or rather flies, under the water with remarkable addreſs, and with apparently equal eaſe in an upward, downward, and horizontal direction, *by muſcular efforts alone!*" (The italics and exclamation are mine.) Pettigrew continues as follows: "An obſervation which may likewiſe be made regarding a great number of fiſhes"—(why not *all?*)—"ſince the ſwimming-bladder or float is in many entirely abſent!" In confirmation he quotes the following from Owen: "The air-bladder is wanting in the dermopteri, plagioſtomi, and pleuronectidæ."—Owen, op. cit., p. 255.

Or to be awakened at midnight by gurgling ſounds of water in your ſtate-room—and no light!—and without waiting to calculate diſtances, you jump down from a top berth and ſuddenly feel ſomething very hard againſt your head, and ſomething very wet all over the floor, the gurgling ſounds going on all the while! It iſn't pleaſant, ſuch things,——for nervous people.

I left New York on Wedneſday, the 3rd of May laſt, in the "Catalonia," Cunard Line. All went well until Sunday, the 7th, four days out, with Newfoundland north of us. It was the Sabbath, clear and beautiful, and all on board were ſo happy! light hearts and ſmiling faces, and not one omen of evil (the ſhip had broken her propeller ſhaft on a former voyage; but this, to me, was good evidence that it wouldn't happen again). It was four o'clock in the afternoon when the ſhaft broke for the *ſecond* time. I had juſt ſtarted for the promenade deck, when a ſound, more terrific to our ears than the burſting of ſeven thunders over head, was ſuddenly heard proceeding from the engine-room; and at the ſame inſtant the deck under our feet commenced to quiver and ſhake with an upheaval like the undulations of great billows. The thumpings and thunderings and bangings in the engine-room were tremendous; the veſſel ſeemed going to pieces, and we in the midſt of the ocean. Nothing about us! Nothing in ſight of us but the everlaſting ſtretch of the great water plain from horizon to horizon. The heavens above us too far to reach, and the waters below us—Ah! ſo deep to ſink into!—and thirty ſeconds ſeemed an age!

To thoſe who have never experienced a ſcene like this my words are meaningleſs.

For thoſe who have, what need of ſaying more?[1]

The theory and practice of building and running ſteamers on the ocean, as far as I have been able to inveſtigate the matter by ſome thirty or forty trips over the

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[1] To prevent a miſapplication of my remarks on the "dignity, &c., of ſhip's officers" on occaſions like the one I have deſcribed, I wiſh to ſay for the captain of the "Catalonia," that this gentleman loſt no time in giving his paſſengers the earlieſt information as to the exact ſtate of the ſhip, and the extent of the accident. No one could doubt the good faith of Captain Gill, and the fears of the paſſengers from any immediate danger were quieted. What we had reaſon to apprehend was, drifting to the north among fields of floating ice and icebergs. But, providentially, we were ſoon in ſight of other veſſels, and all ended well. The "Catalonia" is the eaſieſt veſſel on the waters I was ever in.

Atlantic, appears to be about as follows:—1ſt, *ſpeed;* 2nd, *ſafety;* 3rd, *comfort of tobacco-ſmokers.*

The contact-friction[1] of the water and ſides of the veſſel appears to be left to take care of itſelf; and yet Nature very carefully provides a well-lubricated ſurface for her ſwimmers with means for a continuous lubrication. May it not be that the ſaving in coals would pay for the coſt of oil, or lubricator? The extra ſpeed being ſo much clear gain.

The propelling power of fiſhes depends upon *convolutions:* the convolutions being lubricated, adjuſtible, flexible, inclined planes, capable of tranſmitting, practically, the whole of the motive-power for reacting againſt the water-fulcrum. A very different affair from "ſcrew-propellers."

On the ſcrew I cannot do better than quote again from Pettigrew. At pp. 152,153 he writes as follows:—"In the ordinary ſcrew the blades follow each other in rapid ſucceſſion, ſo that they travel over nearly the ſame particles (whether water or air) in nearly the ſame interval of time. * * * If the ſcrew employed in navigation be driven beyond a certain ſpeed, it cuts out the water contained within its blades: the blades and the water *revolving as a ſolid maſs*. Under these circumſtances the propelling power of the ſcrew is diminiſhed rather than increaſed. * * * The vanes or blades of the ſcrew, as commonly conſtructed, are fixed at a given angle, and conſequently always ſtrike at the ſame degree of obliquity. * * * In this arrangement power is loſt, the two vanes ſtriking after each other in the ſame manner, in the ſame direction, and almoſt preciſely at the ſame moment—no proviſion being made for increaſing the angle and the propelling power at one ſtage of the ſtroke, and reducing it at another to diminiſh the amount of ſlip, incidental to the arrangement."

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[1] The late Thomas Winans, of Baltimore, Md., U.S.A., ſhowed me, ſome twenty-five years ago, the tabulated reſults of his numerous experiments (ſome thouſands, I think) on the friction produced by the paſſage of veſſels through the waters, and its effect on the power of the ſhip; and the reſults were amazing; Mr. Winans remarking, that in his judgment too little attention had been paid to this point. But his ideas, like thoſe of naval architects, for leſſening ſuch friction, were confined to *model:* to leaving the water on lines as ſharp as the entering ones.

I think no one can doubt the correctneſs of the above criticiſm: and the defects appear to me beyond remedy ſo long as the propeller is a *ſcrew*.

Fiſhes propel themſelves by the *tail* and flexible portion of the trunk: and ſcrew-propulſion is deſigned to imitate this method—and may be called the *fiſh* method. But aquatic birds that purſue their prey under water—ſome even going to the bottom of rivers—ſwim with their *wings*. Theſe creatures are a ſort of "ſide-wheelers." And both plans work well.—Why, then, confine ourſelves to the *ſtern-power* method?

If a veſſel were conſtructed with receptacles or concavities in the ſides made within the water-lines and furniſhed with a number of ſmall propellers working within theſe ſpaces—the propellers being capable of adjuſtment to any required angle—ſuch a veſſel ſhould not only be proof againſt ſinking, but ſhould alſo be capable of movement *in any direction* at the will of the engineer, and would alſo have the guarantee of a number of propellers, in caſe of accident, in place of the riſk of only one.

And if veſſels by the application of apparatus worked by motive-power can be floated, why not perſons? Why not mechanical contrivances to leſſen the labour of ſwimming, to make "treading water" eaſy, ſo that people could *walk* out from ſhore to veſſels, and from veſſels to ſhore, making "lifeboats" ſomething more than a name, "life-ſaving" a *certain* "art," rendering *water tricycles* uſeful to merchants and others living out of town on river ſites, beſides much elſe?

Finally, and as I have already remarked, the duty and the work of changing the preſent order of things in the intereſt of all mankind belongs to no ſingle individual. If the theory of mechanical flotation herein ſet forth ſhould prove to be correct, a new field for invention will be opened up, demanding far more inventive talent than can ever be hoped for by any one man, and certainly more than is claimed by

THE AUTHOR.

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